Research Accomplishment: Controlling Order in Confined 2D Layers of Block Copolymer

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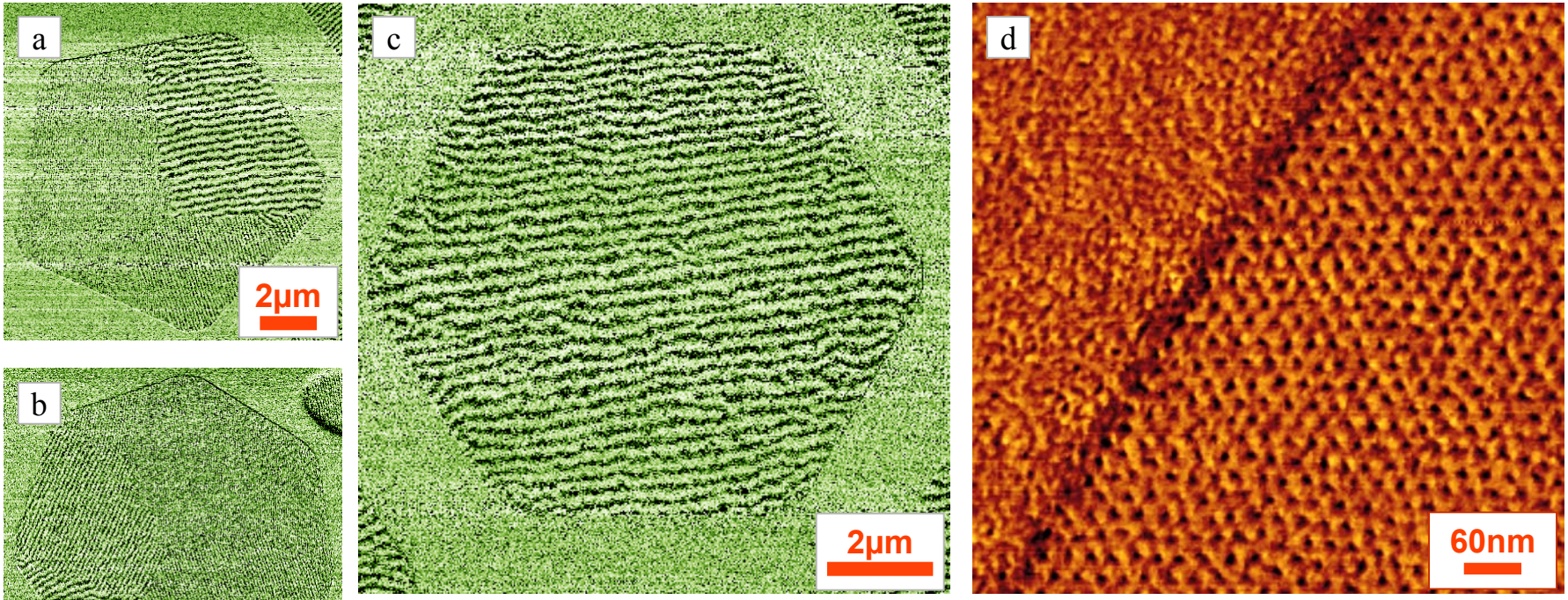
Two-dimensional layers of block copolymer microdomains can be used to pattern arrays of nanoscale features, but controlling the long-range order of the microdomains is a challenge. We demonstrate that topographically patterned substrates will template a single long-range orientation over micrometer length scales, provided the geometry of the substrate is commensurate with the geometry of the block copolymer lattice. A monolayer of the block copolymer forms a hexagonal lattice of spherical microdomains with an intersphere spacing of 29nm, which we confine in silicon oxide wells ranging in size from d = 2-100μm, where d is the diameter of the circumscribed circle. The close-packed rows align with the edges of the hexagons up to at least d = 14 μm. Scanning force microscopy can be used to generate moiré interference patterns that image the lattice orientation over micrometer length scales. Each moiré pattern of fringes corresponds to a unique lattice orientation, and the underlying lattice periodicity and orientation can be calculated directly from the periodicity and orientation of the moiré fringes.



a,b,c: 14.5μm SFM phase images showing moiré interference patterns. Due to the incommensurability of their symmetry with a hexagonal lattice, pentagons and heptagons (a,b) will not template a single grain but a hexagon (c) templates a single grain orientation as evidenced by a single moiré pattern. d: SFM phase image of block copolymer lattice along the edge of a hexagonal well. Close-packed rows are aligned with the edge.

Broader Aspects of Research Accomplishment

Hector Cota

♦ Hector Cota is currently a third year student at Ventura Community College in Ventura, CA. This summer as an REU-INSET student at UCSB he studied the grain structure of spherical block copolymer microdomains confined laterally in hexagonal wells, with an emphasis on the effect of well depth and sidewall angle on the resultant orientation. He presented his results on campus at the Undergraduate Research Colloquium held Aug. 12, 2004. He is enrolled in the physics department at UC Berkeley for the upcoming fall 2004 semester.

Hector Cota with the MultiMode® 3A SFM.

Gila Stein

♦ Gila Stein is a graduate student in the Chemical Engineering Department at UCSB who advanced to PhD candidacy in May 2004 and who served as Hector Cota's mentor during his summer here. Controlling the orientation of 2D block copolymer crystals is a primary component of her thesis. Gila's work has drawn interest from IBM-Almaden and she has begun a collaboration with Dr. Ken Carter there to use his potentially inexpensive nanoimprint lithography to pattern the hexagonal wells needed for alignment. We hope to continue this collaboration after Carter's move to U Mass-Amherst.

Connections with Industry

♦ Templating a single long-range orientation of 2D block copolymer crystals is of interest for nanolithographic patterning. Interactions are developing with nanotechnology groups at IBM, GECR&D and Mitsubishi. The work here demonstrates that substrate topography can be used to control the lattice orientation over length scales much larger than the periodicity of the individual microdomains.

Sergei Magonov

♦ Dr. Sergei Magonov is the "AFM evangelist" with Veeco-Digital Instruments in Goleta, CA. He is a frequent collaborator on developing and using advanced scanning force microscopy techniques, such as the moiré technique shown here.